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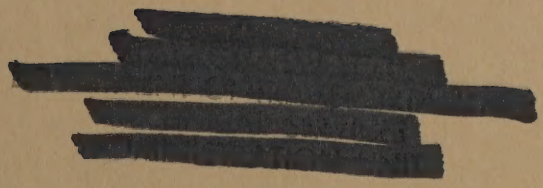
TECHNICAL REPORT 87-4

WEARING SURFACES FOR STEEL ORTHOTROPIC BRIDGE DECKS

FIRST INTERIM REPORT



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NEW YORK STATE DEPARTMENT OF TRANSPORTATION
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TECHNICAL REPORT 87-4

WEARING SURFACE FOR STEEL ORTHOTROPIC BRIDGE DECK
FIRST INTERIM REPORT

CONDUCTED IN CONJUNCTION WITH THE
U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
EXPERIMENTAL FEATURE PROJECT NUMBER 84-01

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March, 1987

MATERIALS BUREAU
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ABSTRACT

The purpose of this study is to evaluate the protective, bonding and durability characteristics of a wearing surface on a steel plate bridge deck. This report describes the design, construction and performance of an experimental system applied on an orthotropic design bridge deck in 1984.

This system was constructed on the South Bay Bridge near Whitehall, New York. It consisted of applying a preformed sheet waterproofing membrane to the steel deck and paving a 2-1/2 inch thick asphalt concrete wearing surface. No problems were encountered during construction and the system is satisfactory after approximately three years.

I. INTRODUCTION

Background

The New York State Department of Transportation owns and maintains two orthotropic steel plate deck bridges. One structure (South Bay Bridge) is located on NY Route 22, north of Whitehall and was built in 1973. The second structure (Webster Street Bridge) is located in the Cities of Tonawanda and North Tonawanda and was constructed in 1978.

On each of these structures the wearing surfaces exhibited early signs of distress shortly after initial construction was complete. To correct these problems each bridge was reconstructed in 1981 using two different experimental wearing surface systems. The experimental wearing system on the South Bay structure failed a second time shortly after its placement. This failure necessitated a second repair in 1984. The wearing surface on the Webster Street Bridge has continued to provide satisfactory performance.

Previous Work

In conjunction with Experimental Feature Project NY 80-09, Technical Report 84-4, Wearing Surfaces for Steel Orthotropic Bridge Decks, was published in June, 1984. This report provided a detailed description of the two orthotropic steel plate bridges; the experimental overlay systems used for their rehabilitation in 1981; and the performance of each system over a two year time period including the failure of one on the South Bay Bridge. To familiarize the reader, an abstract of that report is reprinted below.

ABSTRACT

(Reprinted from Technical Report 84-4, Dated June, 1984)

"The purpose of this study is to evaluate the protective, bonding and durability characteristics of wearing surfaces on steel plate bridge decks. This report describes the design, construction and performance of two systems applied on two orthotropic design bridge decks in 1981.

The first system was constructed on the South Bay Bridge near Whitehall, New York. The wearing system consisted of coating the steel deck with an inorganic zinc-rich silicate paint for corrosion protection: the application of an asphalt emulsion tack coat; a first course paving (1"min, 1-1/2" max.) of Type 7F asphalt concrete; the application of a fabric membrane for waterproofing and crack control; and paving a second course wearing surface of Type 7F asphalt concrete of a thickness of 1" min, 1-1/2" max. A performance evaluation performed 10 months after completion shows failure of this system by debonding and slippage of the asphalt wearing course over the steel deck plates.

The second system was installed on the Webster Street Bridge between the Cities of Tonawanda and North Tonawanda, New York. This system consisted of applying a preformed sheet waterproofing membrane to the steel deck and paving a 2 inch asphalt wearing surface. No problems were encountered during construction and the system is satisfactory after 2 years of service."

Purpose and Scope

This study is being conducted in conjunction with Experimental Feature Project NY 84-01. The purpose of this study is to evaluate the performance of the wearing course system that was used to repair the South Bay Bridge in 1984. This system is the same as that used on the Webster Street Bridge in 1981 and consists of a preformed membrane sheet paved with an asphalt wearing surface.

II. RECONSTRUCTION (SOUTH BAY BRIDGE)

Rehabilitation work was conducted in two stages; work in the southbound lane began in July as specified and was completed in that month; work in the northbound lane was finished by September 1, the required completion date for membrane placement and paving of the entire deck.

Reconstruction consisted of removing the existing wearing course system; applying a proprietary preformed sheet waterproofing membrane for corrosion protection directly on the painted steel deck ; and paving a 2-1/2 inch thick, Type 6F asphalt concrete wearing course. The proprietary waterproofing membrane was "Bituthene 5000" as manufactured by W. R. Grace and Co., Cambridge, Massachusetts.

1. Wearing Course Removal

Southbound Lane - Removal of the deteriorated southbound lane wearing course system was easily performed with little damage to the inorganic zinc-rich silicate paint. As reported in Experimental Feature Project 80-09, no tack coat was evident on the zinc painted steel deck to provide a bond to the overlying asphalt mix.

Northbound Lane - In the northbound lane, the bond between the first course paving and the tack coated steel deck was good. After the major portion of the wearing course system was removed, propane torches were necessary to loosen and remove the well adhered deposits of bituminous mix and tack coat. Solvent cleaning was then used to remove any remaining tack coat.

2. Wearing Course System Placement

Prior to applying the preformed sheet waterproofing membrane, the painted steel deck was waterblasted to remove dirt, rust deposits, and residue. Any flash rusting which occurred due to damage to the painted steel deck was removed by wire brushing or light waterblasting followed by an air blast. These damaged areas were then repainted with a zinc-rich repair material.

The waterproofing membrane "Bituthene 5000" and a 2-1/2 inch thick Type 6F bituminous concrete wearing course were then placed within the specification requirements without any construction problems.

III. PERFORMANCE EVALUATION

In the spring of 1985, the wearing system was evaluated to determine its performance after one winter. Only one minor defect was noted, a recurring problem which was also observed within an identical time period with the previous experimental system.

Hairline cracks (approximately 1/16") were beginning to develop over the longitudinal welded joints between abutting deck sections at each of the four interior girders. These cracks did not appear detrimental and no further deterioration is expected.

The most recent survey in March, 1987 indicates the condition of the wearing course system has not changed since the 1985 evaluation. The hairline cracks are still tight and no additional deterioration was present.

IV. CONSTRUCTION COSTS

A listing of the wearing course system construction items and their costs is shown in Table 1. Other incidental items not directly related to its placement are not listed.

The final cost of this experimental system was $2.75 per square foot which included: removal of the existing overlay and deck surface preparation; waterproofing membrane application; and a 2-1/2 inch Type 6F asphalt concrete overlay.

TABLE 1. WEARING SURFACE SYSTEM COSTS

ITEM NO.	DESCRIPTION	UNIT BID PRICE
581.01	Removal of Bituminous Concrete Overlay (Bridge)	$1.00 Per Sq. Ft.
18558.99	Membrane Waterproofing System For Orthotropic Bridge Deck	$1.00 Per Sq. Ft.
403.1701	Asphalt Concrete - Type 6F Top Course (High Friction)	$50.00 Per Ton ($0.75/sq. ft. for 2-1/2" thickness)

V. FUTURE WORK

Future work on this project will consist of annual performance inspections with interim reports to be issued as necessary, or at minimum three year intervals.

APPENDIX A

SPECIAL NOTE

BRIDGE DECK REPAIR TIME SCHEDULE - FAILURE TO COMPLETE WORK ON TIME

Placement of the new membrane waterproofing system shall not be started prior to July 1, 1984.

It is imperative that this bridge deck repair project be progressed expeditiously to complete placement of the new membrane waterproofing system and wearing surface during the normally warm weather months of July and August. This is required to insure proper compaction of the asphalt and a good bond between the steel deck, membrane, and wearing surface, (as per Special Specification for Membrane Waterproofing System).

The Contractor shall, therefore, intensify his efforts and take appropriate measures to assure completion of the membrane waterproofing system and wearing surface on the bridge, during the months of July and August.

Recognizing the importance of the timely completion of these elements of the work, and in accordance with the provisions of Subsection 108-03, "FAILURE TO COMPLETE WORK ON TIME," of the Standard Specifications of January 2, 1981, the sum of five hundred dollars ($500) per calendar day will be assessed as liquidated damages for failure to complete the installation of the new waterproofing membrane and asphalt wearing surface on the bridge by September 1, 1984. This is not assessed as a penalty, but as liquidated damages for increasing the risk of a poor bond between the deck, membrane, and wearing surface, which may ultimately shorten the service life of the new wearing surface.

The Contractor expressly covenants and agrees that in undertaking this bridge deck repair project, he has taken into consideration and made allowances for all the ordinary delays and hinderances incidental to such work, whether growing out of delays due to weather, or delays in securing materials or workmen; and conditions or restrictions at the site or otherwise.

Unless otherwise specifically provided, no direct payment will be made for any work described by or required by the foregoing Special Note, and the costs thereof shall be included in the prices bid for the various items in the contract.

MAINTENANCE AND PROTECTION OF TRAFFIC
FINAL PAVEMENT MARKINGS

Final pavement markings will be installed by the State at the conclusion of the work. The Contractor shall give State Maintenance Forces two (2) weeks notes in advance of the completion of the Phase II construction sequence. The final removal of all temporary delineation devices shall be coordinated with State Maintenance Forces. The Contractor shall schedule this work operation to allow State Forces to complete the final pavement markings in advance of, or concurrent with, his Phase II withdrawal.

APPENDIX B

SPECIAL NOTE - PROTECTION AND OVERLAYING OF MEMBRANE WATERPROOFING SYSTEM

The bituminous concrete overlay shall be placed on the membrane waterproofing system preferably within 24 hours but not later than seven (7) days after the placement of the membrane system.

The temperature of the bituminous paving material, at the time of placement, shall not be less than 275°F nor greater than 310°F. Bituminous material that is supplied, or allowed to cool to less than 275°F prior to paving shall be rejected. In addition, ambient temperature and the steel plate deck surface temperature at the time of bituminous concrete paving shall be a minimum 60°F.

On grades, bituminous paving equipment shall be operated in the "downhill" direction to minimize damage to the membrane.

Vehicular traffic directly on the membrane system shall be prohibited. Only that equipment necessary for transporting, placing and compacting the overlay shall be allowed on the completed membrane system. Vehicles transporting the overlay material shall be rubber-tired and operated at slow speeds (not to exceed 5 M.P.H.). All vehicles shall avoid making sharp turns, sudden starts and stops, or other movements on the membrane that may cause breaks, lifting, or other damage. If vehicle tires cause pick-up of the membrane small quantities of talc, cement or powdered limestone may be used to dust the tires.

Any damage to the waterproofing system during the overlay operation shall be repaired immediately and prior to the placement of bituminous concrete. A quantity of material shall be kept on hand against such contingency. No additional payment will be made for any areas that require repairs.

Blisters that may raise during the overlay operation shall be vented to insure adhesion of the overlay to the membrane system. Blistered area will be most noticeable during the rolling operation. Venting shall be done by inserting an icepick or other suitable instrument into the affected area. These vent holes need not be repaired.

Bituminous concrete pavers shall be rubber-tired. Track type paving equipment shall not be allowed. The asphalt concrete paving course shall be compacted with smooth steel-wheeled and pneumatic rubber-tired rollers only. Vibratory compaction equipment shall not be allowed.

APPENDIX C

SPECIAL SPECIFICATION

ITEM 18558.99 - MEMBRANE WATERPROOFING SYSTEM FOR ORTHOTROPIC BRIDGE DECK

DESCRIPTION. This work shall consist of furnishing and applying a membrane waterproofing system where indicated on the contract plans, or as directed by the Engineer, and in accordance with this specification. The work shall include the surface preparation of steel plate deck surfaces.

MATERIALS. The membrane waterproofing system shall be the Bituthene Preformed Sheet Membrane System as manufactured by W. R. Grace and Co., Cambridge, Massachusetts and shall consist of Bituthene 5000 Membrane, Bituthene P-3000 Primer, and Bituthene EM-3000 Elastomeric Mastic.

No substitution of another material will be allowed.

CONSTRUCTION DETAILS.

A. General. Preformed sheet membrane installation shall not begin until removal of the bituminous concrete overlay and surface preparation work on the steel deck has been completed and approved by the Engineer.

Membrane installation shall not be done during wet weather conditions nor when atmospheric conditions are such that unsatisfactory results will be produced. The Engineer shall be the sole determiner of favorable atmospheric conditions. No work shall be done when the steel deck surface temperature is below 60°F or when the ambient temperature is below 60°F. The steel deck shall be surface dry at the time of application of the membrane waterproofing system.

B. Surface Preparation. All steel deck surfaces and the surface of vertical joint headers against which the membrane waterproofing system is to be placed shall be cleaned as follows:

1. All loose material, including dirt, gravel, etc. shall first be removed by vacuuming or blowing with compressed air.

2. Any remaining deposits of bituminous concrete overlay that are adhered to the steel deck, or elastomeric joint headers, shall then be removed by hand scraping or chipping or other methods approved by the Engineer. Any removal method that causes severe damage to the zinc-rich paint coating on the steel deck plates or the surface of joint headers will not be allowed.

3. Any loosely adhered or uncured deposits of bituminous tack coat, or heavy deposits of cured tack coat greater than 15 mils (0.015") in thickness shall be removed by solvent cleaning or scraping or other methods approved by the Engineer.

4. Any loosely adhered zinc-rich paint or rust deposits shall be removed by wire brushing or hand scraping. It will not be necessary to repair areas of loose or rusted zinc-rich coating.

5. The entire steel deck surface shall then be rinsed or blasted with fresh water to remove any remaining in-ground dirt or residue that may affect adhesion of the membrane system.

6. Immediately prior to the application of the membrane system, all surfaces to be covered shall be recleaned of dust and other loose material by vacuuming or blowing with compressed air.

To confirm the adequacy of the cleaning, small test patches of membrane shall be applied to any area(s) in question. These test patches shall then be evaluated by the Engineer who may order additional cleaning where poor adhesion is found.

C. Application of Preformed Sheet Membrane System. Prior to application of the sheet membrane material, primer shall be applied to the vertical faces of elastomeric concrete joint headers and allowed to dry in accordance with the manufacturer's recommendations. The height of primer application shall be equal to the height of the completed asphalt concrete overlay.

Primer shall not be applied to any portion of the steel plate deck surface for application of the membrane system.

Primed surfaces which the Engineer determines have become contaminated by dust or dirt shall be reprimed. Primed areas which have not been covered with membrane within 24 hrs. of primer application shall be reprimed. All repriming work shall be done at no additional cost to the State.

Following primer application, flashing strips shall be applied transversely along the joint header where the direction of water drainage is toward the header. Flashing strips shall be defined to mean sections of membrane which are used to waterproof vertical surfaces and seal the intersection of the vertical surface with the steel plate deck. Flashing strips shall extend up the vertical face to a height equal to the finished asphalt concrete overlay and a minimum 6 inches onto the steel plate deck. Flashing strips shall not be applied to the steel plates at the longitudinal paving joints formed by the new and remaining existing pavement.

Twelve inch wide reinforcing strips of sheet membrane shall then be applied longitudinally and centered over the four welded joints at abutting steel plate deck sections prior to the full coverage of the sheet membrane. Ends of the reinforcing strips shall terminate as close as possible to the joint

headers without overlapping flashing strips.

Rolls of preformed sheet membrane shall then be placed longitudinally on the steel plate deck so both the longitudinal and transverse overlaps are formed in the direction of water drainage. Adjacent rolls of sheet membrane shall overlap a minimum of 2 inches on longitudinal laps and 8 inches on transverse laps (Figures 1 and 2). The preformed sheet shall be placed within one inch of the lateral support system (steel plates) installed along each edge of the deck and sealed with mastic. Longitudinal overlaps formed by adjacent rolls of membrane shall not coincide with any portion of the longitudinal reinforcing strips.

Rolls of preformed sheet membrane may be applied by hand or mechanical means. The sheet shall be placed on the deck, sticky side down, by removing the release paper as the work progresses. The membrane shall not be stretched or otherwise placed in tension during the installation. Rolls of sheet membrane shall be placed in such a manner as to minimize wrinkles and bubbles. Stiff bristled brooms shall be used at the time of application to smooth the sheet at its point of contact with the steel deck. To reduce the possibility of "flash rusting" of steel surfaces, close coordination between steel deck cleaning and membrane application is advised.

After the rolls of sheet membrane have been applied to the steel deck, flashing strips shall be applied to the primed vertical face of the joint header and on top of the sheet membrane where the direction of water drainage is away from the vertical face. The vertical termination of all flashing strips shall be sealed with a bead of mastic.

The completed membrane shall be free of large wrinkles, "fishmouths", air bubbles, and other placement defects. These shall be corrected in a manner satisfactory to the Engineer. Where patches are used, the area shall be coated with mastic sealer and pieces of membrane pressed into the sealer over the defective area. The patches shall extend at least 6 inches in every direction beyond the edge of the defect. Bubbles of one inch diameter and greater shall be vented by piercing with an ice pick, or other suitable instrument, and expelling the air. Vented bubbles need not be repaired.

To insure adhesion to the steel plate deck, the preformed membrane and strips shall be rolled with a 100-200 lb. hand roller. If necessary, the face of the roller shall be covered with a suitable material, recommended by the manufacturer, to insure complete membrane contact. Laps which have not been thoroughly sealed by rolling operations shall be sealed with mastic.

When only a portion of the membrane application is completed in one day, the exposed edge of the membrane shall be sealed with mastic.

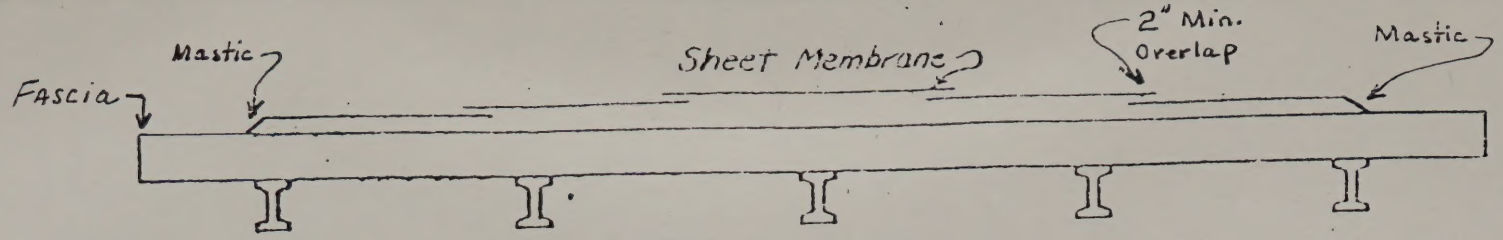
METHOD OF MEASUREMENT. The work shall be measured as the number of square feet of surface area of the steel plate deck covered with the complete membrane waterproofing system. No separate measurement shall be made for reinforcing strips applied over welded joints or for flashing strips applied to the vertical faces of joint headers. No additional measurement shall be made for transverse or longitudinal overlaps formed by rolls of sheet membrane.

BASIS OF PAYMENT. The unit price bid per square foot for this item shall include the cost of furnishing all labor, materials, and equipment necessary to complete the work.

The cost of surface preparation of the steel deck for membrane installation will be included in the unit bid price for this item.

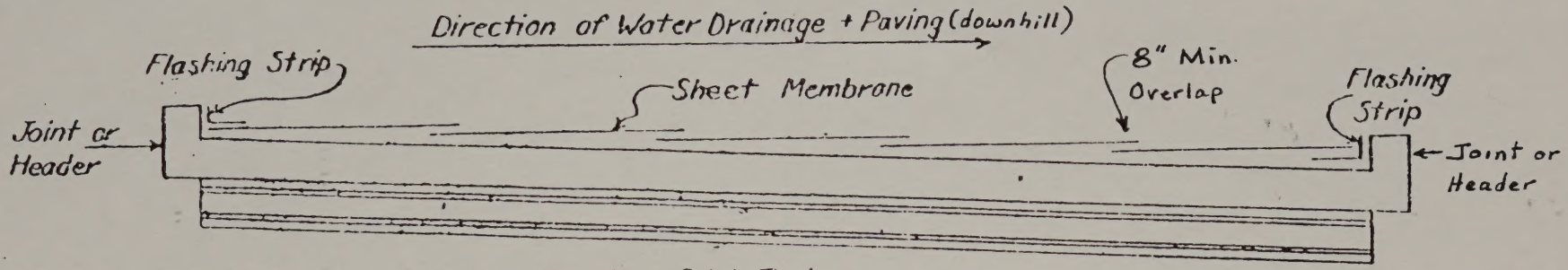
No additional payment will be made for patching damaged areas of the membrane system.

No payment will be made for any work necessitated by damage or defacement attributable to the Contractor's operations.



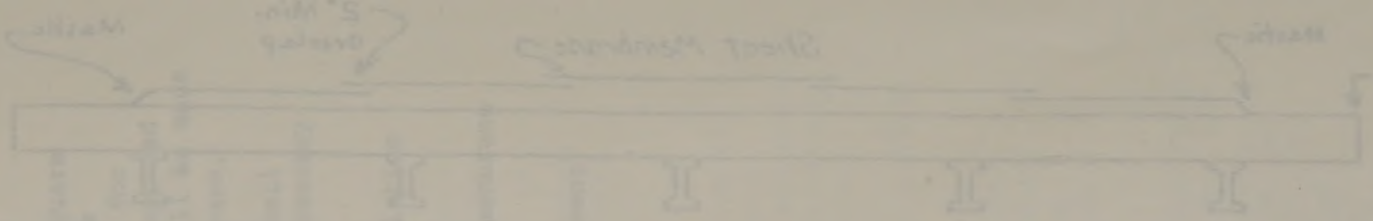
1. Sheet Membrane is installed From Each Fascia Toward The Center with 2" Min. Longitudinal Overlaps.

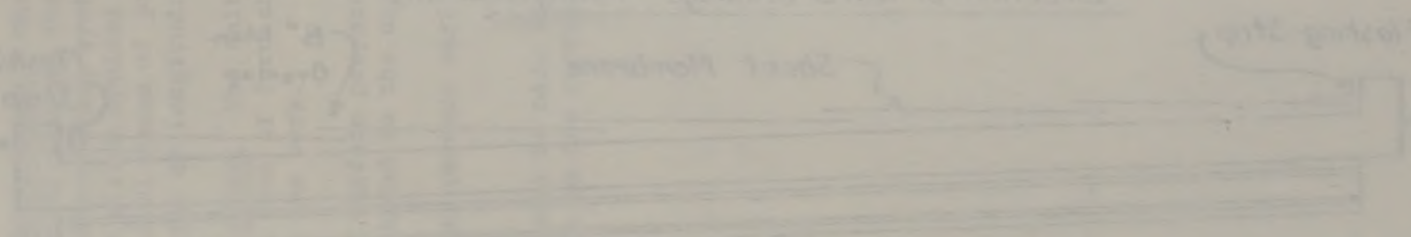
TRANSVERSE SECTION - LEVEL DECK - NO CROSS SLOPE OR NORMAL CROWN - FIGURE 1



1. Flashing Strip Installed Along Low Joint First
2. Sheet Membrane is installed From the Low end of the deck to the high end with 8" min. Transverse Overlaps
3. Flashing Strip Installed Along High joint Last

LONGITUDINAL SECTION - WITH GRADE - FIGURE 2





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